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13. ABSTRACT *(Maximum 200 words)*

This two-experiment study was designed to (1) validate the underlying electronic theory of operation of the Computer Voice Stress Analyzer (CVSA), and (2) examine the decision accuracy and agreement rates using the traditional polygraph instrument and the CVSA. The CVSA input/output was evaluated using simulation signals from lab test generators. Forty-two subjects took psychophysiological detection of deception (PDD) examinations with the polygraph and CVSA instruments, within the context of Peak of Tension (POT) tests using numbers between 3 and 8. Half of the subjects were tested with the polygraph instrument, then the CVSA instrument. The remaining half were tested using the instruments in the opposite order. PDD and CVSA based POT tests were blind-evaluated by four examiners for each instrument. The frequencies of accurate determinations made using each instrument were compared using proportionality tests. The lab simulations established that the CVSA performs electrically according to the manufacturer's theory of operation. The CVSA and associated processes were less accurate than the polygraph and PDD processes tested in similar circumstances (38.7% vs. 62.5%). Interrater reliability, assessed using a multiple rater Kappa test, showed agreement among all blind evaluators within each instrument category was significantly better than chance ($p < .05$). These data indicate there may be a systematic and predictable relationship between voice patterns and stress related to deception.

14. SUBJECT TERMS
voice stress, micro-tremor, CVSA, PSE, PDD, laryngeal, cricothyroid, cricoarytenoid, thyroarytenoid, vagal, interrater reliability

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A Comparison Between Decision Accuracy Rates Obtained Using the Polygraph Instrument and the Computer Voice Stress Analyzer (CVSA) in the Absence of Jeopardy

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August 1995

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Director's Foreword

In recent years, there has been a renewed interest in voice stress applications in Psychophysiological Detection of Deception (PDD) testing. Due to the active promotion through advertising, selling, and training of examiners, the Computerized Voice Stress Analyzer (CVSA) has gained particular prominence among devices designed to use the voice in PDD. The implications for traditional PDD testing are obvious. If a device such as the CVSA is found to be valid, it would be heartily endorsed by Forensic Psychophysiologists. Technology of this nature could theoretically be used to supplement, or even supplant, the equipment and sensors currently used by PDD Examiners. Unfortunately there is a virtual dearth of scientific research regarding the CVSA; from either the promoters or the greater scientific community.

Thus, in accordance with the congressionally mandated requirement for DoDPI to study new technologies and sensors, this important study is the second in a series designed to address issues of voice stress in PDD testing. Specifically, this study was designed to (1) determine if the underlying electronic theory of operation of the CVSA is valid; and (2) compare the decision accuracy and agreement rates between the traditional polygraph instrument and the CVSA. What makes this study unique is that it represents the first comparison of decision accuracy between the CVSA and the traditional polygraph instrument. Such comparisons are scientifically very difficult (and hazardous) due to the normal differences in test formats, pretest interviews, and other procedural differences required by the two approaches. Consequently, a peak of tension format was employed to avoid these differences required by other formats.

As expected, this study found that in laboratory simulations, the CVSA does perform electrically according to the manufacturer's theory of operation. Although the decision accuracy utilizing the traditional polygraph and its procedures was significantly higher than that of the CVSA approach (62.5% vs 38.7%, respectively), both performed at a level greater than chance. While the validity of the traditional polygraph approach has long been established and this study certainly does not establish the validity of the CVSA, it does justify the necessity for further research into the CVSA. As resources permit, DoDPI intends to pursue further scientific inquiry into using aspects of the human voice in the detection of deception.

John R. Schwartz
Acting Director

Acknowledgements

The author wishes to express special thanks to: the volunteers who participated in the study; Sarah Tidwell and Jeff St. Cyr who assisted throughout the study; David Devine and Special Agent Bob Tippett of the Florida Department of Law Enforcement for administering the psychophysiological detection of deception (PDD) and CVSA (computer voice stress analyzer) examinations; Larry Broadwell, John Schwartz, Dr. Gordon Barland, and Dr. William Yankee for evaluating the PDD tests; Dr. Andrew Dollins for his assistance in manuscript preparation; and Lt. Kelly Vaughan of the Martin County (Florida) Sheriff's Office, Detective Robert Neubauer of the Osceola County (Florida) Sheriff's Office, Don Nettles of Nettles and Associates Investigations, Inc., and Sheriff's Deputy Ronald Cucchiara of the Martin County Sheriff's Office for evaluating the CVSA tests. This project was funded by the Department of Defense Polygraph Institute as DoDPI94-P-0027. The views expressed in this article are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

Abstract

CESTARO, V. L. A comparison between decision accuracy rates obtained using the polygraph instrument and the computer voice stress analyzer (CVSA) in the absence of jeopardy. April 1995, Report No. DoDPI95-R-0002. Department of Defense Polygraph Institute, Ft. McClellan, AL 36205.--This two-experiment study was designed to (1) validate the underlying electronic theory of operation of the Computer Voice Stress Analyzer (CVSA), and (2) examine the decision accuracy and agreement rates using the traditional polygraph instrument and the CVSA. During Experiment 1 the CVSA input/output was evaluated using simulation signals from laboratory test generators. During Experiment 2, 42 subjects took psychophysiological detection of deception (PDD) examinations administered with the polygraph and CVSA instruments within the context of Peak of Tension (POT) tests using numbers between 3 and 8. Half of the subjects were tested on the polygraph instrument, then the CVSA instrument. The remaining half were tested using the instruments in the opposite order. PDD and CVSA based POT tests were blind-evaluated by four independent examiners for each instrument. The frequencies of accurate determinations made using each instrument were compared using proportionality tests. The laboratory simulations established that the CVSA performs electrically according to the manufacturer's theory of operation. However, the CVSA instrument and associated processes were less accurate than the polygraph instrument and PDD processes tested in similar circumstances (38.7% vs. 62.5%). Interrater reliability, assessed using a multiple rater Kappa test, showed that agreement among all blind evaluators within each instrument category was significantly better than chance ($p < .05$). These data indicate there may be a systematic and predictable relationship between voice patterns and stress related to deception.

Key-words: voice stress, micro-tremor, CVSA, PSE, PDD, laryngeal, cricothyroid, cricoarytenoid, thyroarytenoid, vagal, interrater reliability

Executive Summary

CESTARO, V. L. A comparison between decision accuracy rates obtained using the polygraph instrument and the computer voice stress analyzer (CVSA) in the absence of jeopardy. April 1995, Report No. DoDPI95-R-0002. Department of Defense Polygraph Institute, Ft. McClellan, AL 36205.

The use of voice analysis equipment for detecting deception in spoken responses has had mixed reviews for many years. The results of laboratory studies within a psychophysiological detection of deception (PDD) paradigm, using first generation voice analysis instruments such as the psychological stress evaluator (PSE), frequently have not supported the claims made by the proponents and manufacturers of the equipment. Additionally, the underlying electrical and physiological theories of operation, particularly concerning voice microtremor, have not been adequately supported by the results of controlled laboratory research.

This two-experiment study was designed to examine the CVSA, which recently supplanted the PSE. Experiment 1 was designed to examine and validate the electronic theory of operation underlying the CVSA. Electronic function generators were used to simulate the range of human voice microtremor--which was input to the CVSA instrument. These simulations obtained CVSA outputs which were consistent with the manufacturer's theory of operation. The second experiment was designed to compare decision accuracy rates obtained using the CVSA instrument and processes with those obtained using the traditional polygraph instrument and processes under identical test conditions. Forty-two subjects were tested using the CVSA and the polygraph instrument employing a Peak of Tension numbers test. Half of the subjects were tested using the CVSA, then the polygraph instrument. The remainder were tested using the polygraph instrument, then the CVSA. The examination results showed that the polygraph instrument and processes were more accurate than the CVSA instrument and processes in determining subject veracity (62.5% vs. 38.7%), and that this difference was statistically significant ($p < .05$). However, interrater reliability among four examiners who blind-evaluated tests within each instrument category, was significantly different from chance levels ($p < .05$), indicating consistency among evaluators' scoring abilities irrespective of instrument type.

The results of this study suggest that (1) the CVSA instrument detects discrete changes in fundamental frequency; (2) under non-stressful test conditions, the CVSA instrument and processes are less sensitive to psychophysiological reactivity than are the polygraph instrument and associated processes; and (3) the observed difference in accuracy rates are related to instrument sensitivity rather than to examiner test evaluation skills.

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Voice analysis is the decomposition of a human voice into objectively measurable characteristics. It has been proposed that voice analysis can be used to determine the amount of stress (voice stress analysis) that the speaker is experiencing (Brenner, Branscomb, & Schwartz, 1979; Inbar & Eden, 1976). Instruments designed to detect deception, such as the polygraph instrument, do not detect deception per se, but rather detect physiological activity related to the stress experienced by subjects during the act of deception. According to reports published in the National Institute for Truth Verification (NITV) Journal of Continuing Education (1995), the detection of deception using voice stress analysis is rapidly gaining acceptance and getting favorable reviews from many law enforcement agencies. Although reviews of the accuracy of voice analyzers, such as the Psychological Stress Evaluator (PSE, Dektor Counterintelligence and Security, Springfield, VA) have been mixed (e.g., Horvath, 1978, 1979, 1982; VanDercar, Greaner, Hibler, Spielberger, & Block, 1980), the acceptance of instruments employing this technique has been facilitated by their ease of use, non-invasiveness, and short training period required for prospective operators.

The Computer Voice Stress Analyzer (CVSA) manufactured by the NITV (West Palm Beach, FL) is the latest in a series of instruments purported to detect deception. The manufacturer's product brochure claims that state of the art computer technology is employed to process voice responses in real time. Previous equipment, such as the PSE, consisted mainly of a simple resistor-capacitor low pass filter circuit , and required responses to be recorded on audio tape and subsequently analyzed at reduced taped speed (Vandercar, et al., 1980). The CVSA analyzes and displays responses in real time, purportedly using state of the art computer technology. Responses do not have to be pre-recorded and then played back at the 1/4 to 1/8th speed required by the PSE.

Surprisingly, no controlled laboratory research has been conducted to test the validity or reliability of the CVSA instrument or the techniques employed in its use, nor are there any indications that it meets or exceeds the accuracy rates reported for the traditional polygraph instrument. The testimonials in the NITV journal regarding the efficacy of the CVSA lean heavily on its utility in obtaining admissions (confessions), and its ease of use. The high accuracy rates claimed by the manufacturer are based on field data rather than laboratory research, as stated by Dr. Charles Humble, president and founder of the NITV (G. Barland, personal communication, June 12, 1989):

> The CVSA is a computerized voice stress analyzer that is based on the older Psychological Stress Evaluator. As you are aware, the research concerning the validity of the PSE has always been controversial and never accepted in polygraph circles. The validation of the CVSA was accomplished by utitizing (sic) the audio portion of 75 known-conclusion cases. Twenty of these were NDI and 55 were DI. The CVSA correctly called all of the cases for a correlation rate of 100%.
>
> Rather than rely on laboratory studies which I do not feel accurately reflect the validity of either the polygraph or the CVSA, I would refer to field studies which, in my opinion, do.

[Note: NDI = No Deception Indicated, DI = Deception Indicated]

Manufacturers and proponents of voice stress analyzers claim that the reason for the failure to obtain high accuracy rates in analog (laboratory) studies is the low level of jeopardy in "game playing" laboratory scenarios (Horvath, 1982). Webster's Dictionary defines jeopardy as "exposure to loss, or damage". Individuals submitting to a detection of deception examination outside of the laboratory usually experience some jeopardy in association with the examination while those submitting to a detection of deception examination in the laboratory, a contrived situation, do not. Tippett (1995) states that previous testing has shown that artificially induced jeopardy produced only marginal results with the CVSA. He argues that when at least a moderate level of personal jeopardy was perceived by subjects, the CVSA and the polygraph instruments and processes were equally effective in determining truth or deception. In a study conducted by Tippett (1995), 54 subjects who were undergoing mandatory private therapy related to past sex offenses were tested using the CVSA and the polygraph instrument. According to Tippett, "...there was a 100% agreement between the CVSA and the polygraph". He concluded that the CVSA is as effective as the polygraph instrument for detecting deception.

The personal jeopardy requirement can cause uncertainty in testing, as Horvath points out (1982, p. 344) when he asks, "...if there is a certain degree of jeopardy (stress) necessary to obtain valid results with the voice stress devices, as the proponents also claim, what is the threshold and what is the criterion by which one determines it?" Horvath (1982) also questioned how the PSE was developed and perfected if it could not be tested in experimental situations. Nonetheless, it was found that PSE, the State/Trait Anxiety Index, and heart rate measures covaried and reflected levels of stress in the first portion of a pair of studies conducted by VanDercar, Greaner, Hibler, Spielberger, and Block (1980). The failure to validate the PSE in the second study was attributed to lower levels of induced stress. Furthermore, Barland (1974), in a low stress/high stress study, demonstrated that the PSE achieved significantly high accuracy rates when stress levels were high, but did not do so with low stress levels. However, Lynch and Henry (1979) found no evidence that the PSE could discriminate between stressful and non-stressful responses at greater than chance levels. In studies where jeopardy has been defined in terms of motivation (e.g., monetary loss or gain) to pass or fail a detection of deception examination, the results have been mixed. Gustafson and Orne (1963) reported that detection rates were greater in subjects who were motivated than in subjects who were not. However, Lieblich, Naftali, Shmueli, and Kugelmass (1974) claimed that motivation had no significant effect on detection rates. Additionally, Horvath (1979) has shown that increased motivation does not improve the detection of deception with the PSE. Brenner, Branscomb, and Schwartz (1979) also question the validity of the PSE in the context of deception detection, although some aspects of the analysis may be valid for the measurement of stress.

The underlying theory of operation for the PSE and the CVSA proposes that the instruments detect physiological microtremor associated with muscles in the voice mechanism. Physiological tremor is described as a low amplitude oscillation of the reflex

mechanism that controls the length and tension of a stretched muscle, and has a frequency between 8 and 12 hertz (Hz) (Lippold, 1971). According to Lippold, tremor is believed to be a function of the signals to/from motor neurons and is analogous to a self-adjusting, closed-loop servo system, and that the observed tremor is like the "hunting" behavior of mechanical servomechanisms. Stretch sensors in the muscle tissue signal the amount of stretching and transmit this information to the associated motor neuron in the spinal cord. This information is processed and the efferent motor neuron fiber is activated to increase or decrease the stretch of the muscle tissue. The finite delays in signal transmission to and from the target muscle account for the low frequency oscillation, and hence, the hunting behavior. Voice stress analyzers purportedly detect physiological microtremor in speech (oscillations of 8 to 12 Hz in muscle tissue), and convert those components to a graphical representation of physical stress being experienced by the subject under test (Brenner, Branscomb, & Schwartz, 1979). Nerve fibers carried in the trunk of the vagus nerve innervate the laryngeal muscles, including the cricothyroid muscle (Kahane, 1986). Increases in voice frequency are accomplished by lengthening the vocal folds through activity of the cricothyroid muscle, while decreases are a result of relaxation and shortening of the vocal folds by the thyroarytenoid muscle (Gray, 1977, p. 963). Laryngeal microtremor, indirectly assessed by analysis of changes in voice fundamental frequency, is purported to be inversely related to stress. It is argued that as stress increases, the amplitude of the microtremor decreases (Smith, 1977). Support for the laryngeal microtremor hypothesis is inconsistent (Shipp & Izdebski, 1981; Inbar & Eden, 1976). Shipp and Izdebski (1981) found no evidence to support the laryngeal microtremor hypothesis. These investigators examined EMG (electromyographic) activity directly from the laryngeal muscles (cricothyroid and posterior cricoarytenoid) during conversational speech and sustained phonation. They contend that EMG activity changed so rapidly over time during normal speech that no Fourier analysis could be calculated at the selected sampling rate. These signals were compared to normal microtremor of 9 Hz sampled from the biceps. They concluded that their findings cast doubt on the assumptions made by manufacturers of (voice) stress analysis instruments. Conversely, Inbar and Eden (1976), using similar procedures, found that EMG recordings were correlated with frequency changes in the voice spectrum, suggesting the existence of voice microtremor.

Voice stress research using instrumentation other than off-the-shelf voice stress analyzers has focused on discrete measures within the response as indicators of deception. Motley (1974) reported that response duration was the only reliable index of deception. Other investigators have shown that stress is related to a specific change in the fundamental frequency of the speaker's voice (Tolkmitt & Scherer, 1986; Streeter, Krauss, Geller, Olson, & Apple, 1977). Cestaro and Dollins (1994) calculated spectrum and time domain analyses of voice responses recorded during 28 POT PDD examinations. They found no single measure of the voice response that could serve as a reliable indicator of deception. While a systematic relationship was found among some combinations of speech parameters and stress, the relationship was not consistent over time and between subjects. No systematic relationship was found between voice spectra and stress. Others have reported that speaker

stress could not be related to the results of voice response spectral analysis (Zalewski, Majewski, & Hollien, 1975).

This two-experiment study was designed to evaluate a second generation voice analyzer, the CVSA, in theory and practice. According to the manufacturer, the CVSA detects stress related changes in the voice (laryngeal) microtremor (NITV, 1994). Experiment 1 was designed to determine whether the CVSA instrument detects microtremor in the fundamental frequency of presented signals--as the manufacturer claims. Experiment 2 was designed to determine if accuracy rates obtained using the CVSA instrument and procedures differed from those obtained using the traditional polygraph instrument and procedures.

Experiment 1

The purpose of Experiment 1 was to test the theory of operation of the CVSA. The manufacturer claims that changes in the fundamental frequency of a signal presented at the input to the instrument are displayed as meaningful changes in the chart tracings. Tracings with a constant, or nearly constant, amplitude are said to contain little or no microtremor, and are indicative of a stressed response. Conversely, tracings showing a cyclic or peaked pattern are said to be the result of microtremors in the response, and are indicative of a response containing little or no stress. Laboratory function generators were used to simulate stressed and unstressed voice responses presented to the input of the CVSA. Constant amplitude unmodulated signals were used to represent a stressed voice response containing no microtremor. Unstressed responses were simulated by frequency modulating the function generator at a 10 Hz rate. The resultant CVSA output was examined at various fundamental frequencies.

Method

Apparatus

A Tektronix (Beaverton, OR) Model CFG280 Function Generator was used to present a constant amplitude sine wave signal to the microphone input of the CVSA. A Tektronix Model CFG250 Function Generator was used to modulate the frequency of the CFG280 signal and simulate speech microtremor. Frequency was verified with a Tektronix CDC250 Universal Counter. A Tektronix Model 2247 Oscilloscope was used to monitor the amplitude and frequency shift of the signals from the CFG280 Function Generator.

Procedures

The CFG250 Function Generator was used to present a linear ramp (sawtooth) input to the modulation input of the CFG280 Function Generator. The starting frequency for the CFG280 Function Generator was initially adjusted with zero volts applied to the modulation input. The frequency of the signal on the output of the CFG280 Function Generator was then increased linearly by application of a positive-going linear voltage ramp at the modulation input. The CFG280 Function Generator has a modulation transfer function such that the instantaneous output frequency is a function of the instantaneous amplitude of the

signal presented to the modulation input. The amplitude of that signal was adjusted so that the CFG280 provided a frequency modulated carrier signal to the CVSA, varying linearly from a starting frequency of 100 Hz to an ending frequency of 1000 Hz. The amplitude of the sine wave output of the CFG280 was limited to 8 millivolts peak-to-peak for most of the tests. The resulting output from the CVSA was recorded on 2 inch (508 mm) heat sensitive paper normally used for recording. Frequency and time were recorded respectively on the vertical and horizontal axes of the chart paper as shown in Figures 1 through 10. The ramp test was repeated using 500 Hz and 2500 Hz, respectively, as start and stop frequencies. The response of the CVSA was also recorded using unmodulated, or continuous wave signals, and frequency modulated (FM) signals. The modulation frequency was fixed at 10 Hz to simulate microtremor with an amplitude sufficient to achieve approximately 25% modulation from the target function generator. The 25% modulation level was arbitrarily selected since there are no known data that would suggest any other level. Response patterns were checked at 200 Hz, 500 Hz, and 1000 Hz to assess CVSA system linearity. The sensitivity setting on the CVSA was adjusted so that the light emitting diode range indicator on the CVSA instrument front panel stayed within the normal range during signal acquisition. Chart sizing was adjusted to provide normal pen deflections on the CVSA prior to each simulation.

Results

Laboratory test results indicate that the CVSA pen vertical position is dependent on the input frequency, within a narrow linear range (see Figures 1 and 2). When the CVSA input was an 8 millivolt sine wave, the frequency of which was increased linearly from 100 to 1000 Hz - as illustrated in Figure 1 - midscale corresponded to approximately 350 Hz. Figure 2 depicts the response relationship between frequency and pen position from 500 Hz to 2500 Hz. CVSA frequency response appears to be linear from 100 Hz to 600 Hz. Between 600 Hz and 2000 Hz, a gradual non-linear response pattern is observed in the CVSA output (Figures 1 and 2). Above 2000 Hz, the frequency response rolls off rapidly to become nearly flat.

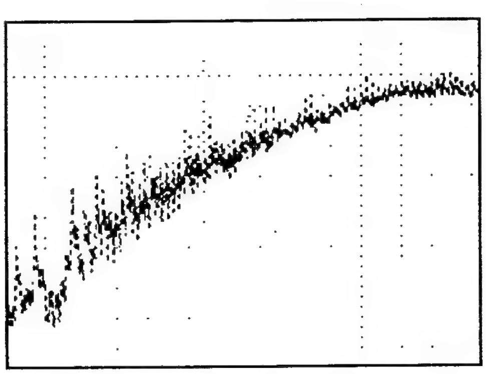

Figure 1. CVSA output when the input is an 8 millivolt peak-to-peak sine wave, swept from 100 to 1000 Hz.

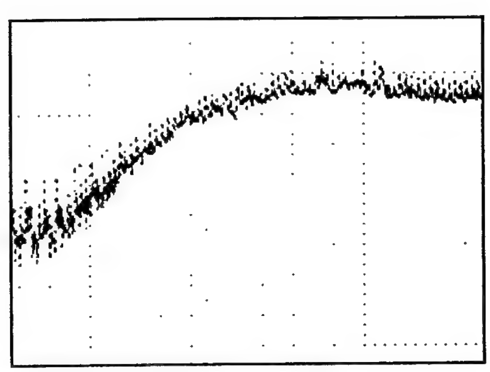

Figure 2. CVSA output when the input is an 8 millivolt peak-to-peak sine wave, swept from 500 to 2500 Hz.

Injecting a 200 Hz continuous sine wave signal into the microphone input of the CVSA resulted in the CVSA output shown in Figure 3. Figure 4 shows the same 200 Hz fundamental frequency input signal with 10 Hz FM modulation and approximately 25% modulation. A cyclic pattern is evident, as predicted by the manufacturer's theory of operation. In accordance with that theory, the signal depicted in Figure 3 would correspond to a stressed (deceptive) response, while that of Figure 4 would indicate the absence or reduction of stress (truthful response). Similar response patterns are seen in Figures 5 and 6 (fundamental frequency = 500 Hz), and in Figures 7 and 8 (fundamental frequency = 1000 Hz).

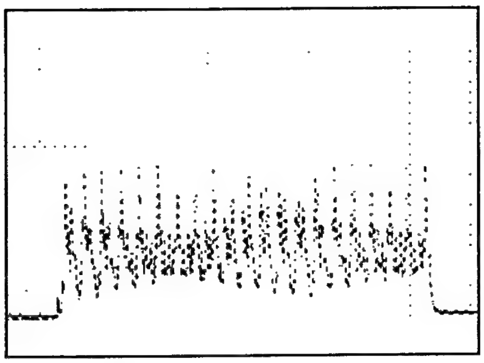

Figure 3. CVSA output when the input is an 8 millivolt peak-to-peak 200 Hz sine wave (stressed response).

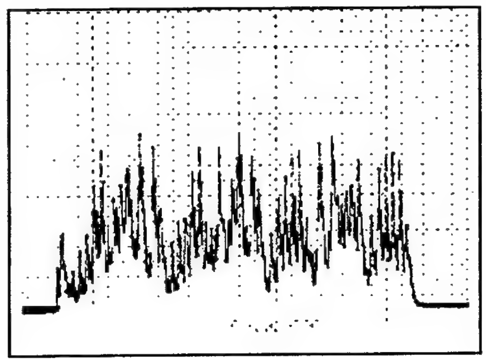

Figure 4. CVSA output when the input is a 200 Hz sine wave modulated at a 10 Hz rate (unstressed response).

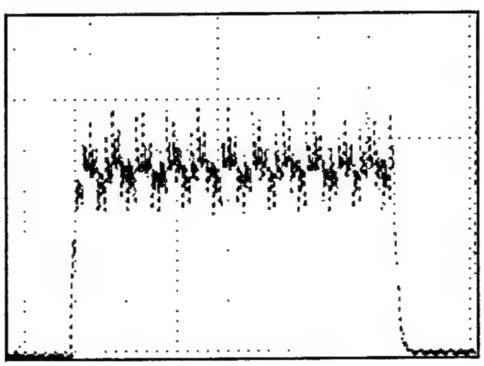

Figure 5. CVSA output when the input is an 8 millivolt peak-to-peak 500 Hz sine wave.

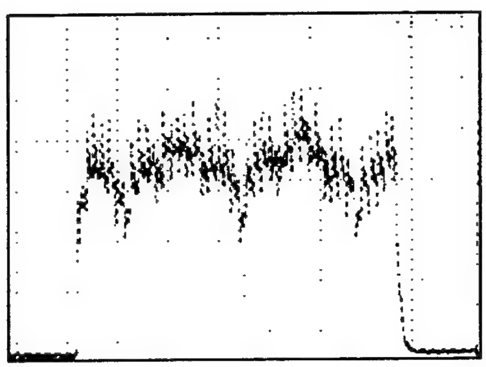

Figure 6. CVSA output when the input is an 8 millivolt peak-to-peak 500 Hz sine wave modulated at a 10 Hz rate.

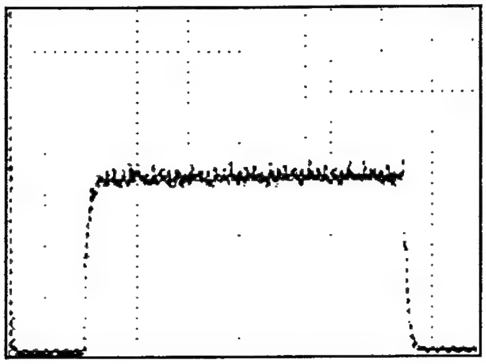

Figure 7. CVSA output when the input is an 8 millivolt peak-to-peak 1000 Hz sine wave.

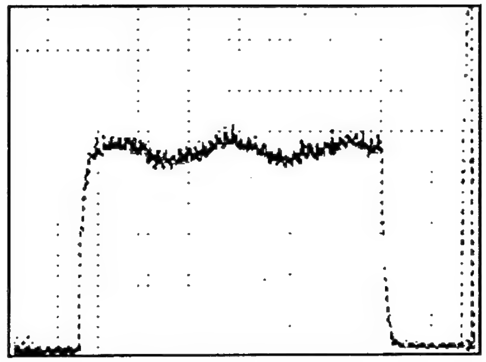

Figure 8. CVSA output when the input is an 8 millivolt peak-to-peak 1000 Hz sine wave modulated at a 10 Hz rate.

Increasing the amplitude--but not the frequency--of the signal injected into the CVSA microphone input (i.e., an increase in signal strength) resulted in a decrease in the amplitude modulated baseline component of the CVSA output, as shown in Figures 9 and 10. The signal riding on the detected FM may be front end or discriminator noise, which is reduced in amplitude as the input signal amplitude is increased (i.e., FM quieting increases as the signal to noise ratio gets larger). In the CVSA the undetected AM component (noise) is largely a function of variations in carrier level (fundamental frequency amplitude). The FM detector responds primarily to changes in the carrier frequency (microtremor), with an output voltage change proportional to the change in frequency (Figures 4, 6, and 8).

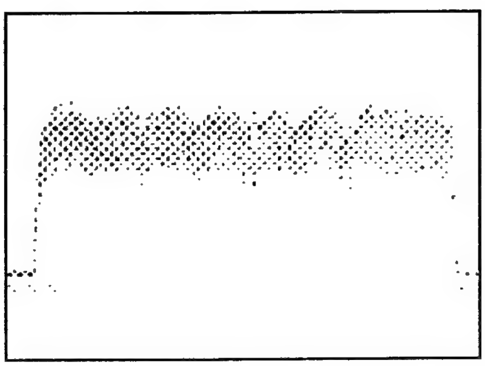

Figure 9. CVSA output when the input is an 8 millivolt peak-to-peak 300 Hz sine wave.

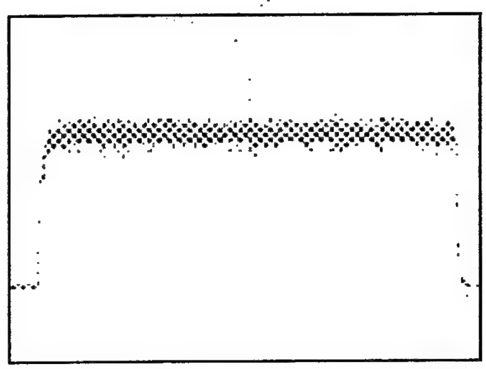

Figure 10. CVSA output when the input is a 32 millivolt peak-to-peak 300 Hz sine wave.

Discussion

Results of laboratory tests indicate that the CVSA functions electrically according to frequency modulation detection theory. It was found that discrete changes in the frequency of the input signal caused discrete deflections of the CVSA pen, and that the amplitude of those deflections was proportional to the frequency of the input signal. Increases in the

amplitude of the input signal resulted in reduction of the amplitude of extraneous (noise) signals on the CVSA chart tracings. These findings are consistent with the manufacturer's theory of operation. Thus, if there is an inverse relationship between stress and voice microtremor amplitude, and those changes have sufficient signal value to be detected by the CVSA, it should be possible to see pattern changes in the CVSA output under different levels of stress. Those issues were addressed in Experiment 2.

Experiment 2

In Experiment 2, the CVSA and the polygraph instrument were used to test subjects within a POT numbers test paradigm. Subjects picked a number between 3 and 8 and were instructed to answer "no" to all questions concerning the number chosen. It was expected that a stressed response to the key number would be detected by the CVSA and the polygraph instrument and would be discriminable from all other responses. Four evaluators within each instrument category, who were not aware of the numbers selected by subjects, made decisions regarding the number selected solely by examination of the paper charts collected during test administrations. Accuracy rates obtained by these evaluators for both instruments and procedures were examined. Additionally, interrater agreement was assessed among evaluators within each instrument category.

Method

Subjects

Forty-two subjects recruited from the U.S. Army training command at Fort McClellan and a local civilian contract agency were randomly assigned in equal numbers to each of two groups. One group took the PDD examination followed by the CVSA, while the other group took the examinations in the reverse order. Subjects were 22 males and 20 females between the ages of 19 and 35 years.

Apparatus

A polygraph instrument (Lafayette, Lafayette, IN, Factfinder Model 76740/76741) was used to record skin resistance, respiratory, and cardiovascular activity on paper charts. A CVSA (NITV, West Palm Beach, FL) was used to record and display voice response data on paper charts. A lapel microphone (Radio Shack, Fort Worth, TX, Model 33-3003) was connected to the audio input jack of the CVSA to present voice responses to the instrument. A voice recorder (TEAC, Montebello, CA, Model 134B) was used to collect voice responses for off-line analysis. A lavaliere microphone (Shure, Evanston, IL, Model 570S) was used with the audio recorder to record subjects' verbal responses. A desktop IBM compatible computer was employed to replay questions throughout testing in both portions of the study.

The questions presented to the subjects were digitized and recorded to computer hard disk using a Sound Blaster board (Model 16ASP, Creative Labs Inc., Milpitas, CA). A parallel port interface, designed and fabricated in-house, connected to a Radio Shack (Fort Worth, TX) integrated stereo amplifier (Model SA-155) and two Radio Shack speakers (Model Minimus-77) was used to present questions. This system ensured that each question was presented during the PDD examination and the CVSA examination with the same inflection, and at the same volume, each time it was asked. The question presentation software also controlled the TEAC recorder through an RS-232 interface designed in-house.

Examiners

A certified PDD examiner, who had administered more than 5000 examinations over a 30-year period, conducted the PDD portion of the study. A second certified PDD examiner, also trained and experienced in CVSA use by NITV, conducted the CVSA portion of the study. This examiner had over one and a half years PDD experience encompassing 150 examinations, and had also administered 450 CVSA examinations during a two and a half year period. Four additional certified PDD examiners, who were unaware of subjects' number selections, independently evaluated the polygraph tests to determine the number selected by each subject. The CVSA tests were also independently evaluated by four trained and certified CVSA examiners. Two of these examiners were also trained and certified PDD examiners.

Design

The standardized DoDPI acquaintance (stimulation) test, using a Known Solution POT test was employed for subject testing. The 42 subjects were pseudo-randomly assigned to each of two 21 subject groups. One group was tested with the polygraph instrument first, followed by CVSA testing. The other group was tested with the CVSA first, then the polygraph instrument, to counterbalance the order of testing. Within each group, half of the subjects were randomly assigned to Key A (third question is the key number), and half to Key B (the fourth question is the key number). Each subject was tested using six numbers in sequence. No more than three subjects having the same key position were tested consecutively by either examiner. Since the relevant questions for the two examinations were identical, digitized voice was used to present the questions to the subjects. The only difference between the two examinations was the inclusion of irrelevant questions in the CVSA test question format. Data from the PDD and CVSA examinations were independently assessed by four additional examiners who were unaware of subjects' key numbers. The dependent measures were the number of correct determinations, and the number of concurrent determinations made using the two instruments and their processes.

Procedures

Upon arrival at the DoD Polygraph Institute (Fort McClellan, AL), each participant was escorted by a member of the research team to a secluded briefing room and asked to read a

brief description of the research project (Appendix A). Individuals indicating that they would participate were asked to read and sign an informed consent affidavit (Appendix B). A brief biographical / medical questionnaire was completed, to ensure that the participant was in good health and not currently taking medication which could interfere with the examination results (Appendix C). The subject was then escorted to one of the examination rooms, determined by order assignment, for testing. The examinations were then administered as described below. When both the PDD and CVSA examinations were completed, the subject was escorted back to the briefing room for subject debriefing, and to read and sign a debriefing statement (Appendix D).

Procedures common to CVSA and PDD. The examiner conducted the pre-test interview (Appendices E and G) prior to placing the sensors on the subject. The subject was told to select a number between 3 and 8, not 3 or 8, and to write the number selected, one to two inches in height, in the middle of a sheet of paper. The examiner was given the key number position for each subject in order to properly pad the sequence of numbers. The examiner then wrote the padding numbers above and below the number written by the subject and placed the sheet of paper on the wall directly in front of the subject. The Key A sequence used two "padding numbers" before and three after the number picked by the subject. The Key B sequence used three padding numbers before and two after the key number (see Appendix F). The subjects were instructed to answer "no" to the questions concerning numbers, even if it meant that they would be lying about the number they chose.

PDD procedure. If the CVSA examination was administered prior to the PDD examination, the previously selected number was used again. The POT test was then administered according to the procedures taught at the DoDPI, with the exception that the post-test interview was not conducted. In order to comply with the philosophy of the CVSA examination procedure to avoid situational stress, no psychological set was required, and the post-test would have served no purpose in this study. If the PDD examination was administered before the CVSA examination, the subject proceeded immediately thereafter to the CVSA examination.

CVSA procedure. If the PDD examination was administered prior to the CVSA examination, the previously selected number was used again. The examiner conducted the pre-test interview (Appendix G) in a manner to remove any situational stress associated with detection of deception examinations. The lavaliere and lapel microphones were then placed on the subject and the CVSA instrument was calibrated for the subject's voice level. The question sequence was in the CVSA POT format (IR-IR-R-IR-R-IR-R-IR-R-IR-R-IR-R-IR) where IR = irrelevant and R = relevant. Irrelevant questions had no connection to the issue at hand, caused no stress of themselves, and were known truth (e.g., "Am I wearing a tie?"). Relevant questions consisted of numbers from the same set used during the PDD exam.

The CVSA examiner conducted two tests. The first test was discarded to avoid scoring data confounded by situational stress. The second test was retained for scoring. All

examinations were recorded on audio and video tape for off-line analysis to confirm the live results.

Data Reduction and Analysis

Test evaluation. Each PDD test was independently evaluated by each of four certified PDD examiners. CVSA tests were independently evaluated by each of four certified CVSA examiners, trained by the NITV. PDD test data evaluation consisted of selection of the response showing the most reactivity, according to traditional PDD procedures. CVSA test data evaluation consisted of selection of the response showing the highest percentage of "blocking" (i.e., rectangularity) on the relevant/associated irrelevant, in accordance with accepted CVSA scoring practices. Although data analysis procedures were clear and explicit (Appendix H), evaluators were not given the padding information (two or three padding numbers) in order to avoid the possibility of biased scoring. However, all evaluators were told that there was at least one padding question before and after the key question (i.e., the key number will never be in the first or last position in the sequence), leaving only four responses to be scored.

Data reduction. The dependent measures were: the number of times a scorer correctly identified the number selected by a subject and; the frequency that evaluators using different instruments and processes identified a subject as being deceptive to the same question, irrespective of the accuracy of the decision. Data were transformed from number sequence (1 to 10) to serial position of those numbers in the test series, adjusted for the two padding sequences. Regardless of the starting number in a subject's sequence, all scored numbers would fall into the range 1 through 4, with the key appearing only in position 2 or 3. Each scorer had 1 chance in 4 of correctly identifying the key by chance alone.

Data analyses. Analyses included a test of the significance of the proportionality between correct number determinations and chance accuracy (25%). Effects of examination order on mean accuracy were also examined. A power analysis performed prior to the study indicated that with N= 42, power > 0.90 for the expected effect size (0.25). The Fleiss (1981) multiple rater Kappa test was used to independently assess decision agreement among the four evaluators within each instrument category.

Results

Evaluator Accuracy

PDD evaluators correctly identified the correct key number in 105 of 168 total trials, achieving a statistically significant overall accuracy of 62.5% ($p < .05$), with a range of 57% to 69%. Three of the four evaluators obtained accuracy rates equal to or greater than 60%. The CVSA evaluators correctly identified the correct key number in 65 of 168 total trials, obtaining a nonsignificant overall accuracy of 38.7%, with a range of 24% to 45%. Three of the four evaluators achieved accuracy rates equal to or greater than 40%. The

difference (23.8%) between mean accuracy rates obtained using the two instruments and their procedures was statistically significant ($p < .05$).

Order Effects on Accuracy

The order of examination administration had an effect on the accuracy of each instrument; accuracy declined on the second series of tests. The PDD mean accuracy obtained using the polygraph instrument was 75%($p < .05$) for the group undergoing the PDD examination before the CVSA examination. The mean accuracy obtained using the polygraph instrument was 50% ($p < .05$) for the group undergoing the CVSA examination before the PDD examination. Similarly, when the PDD examination preceded the CVSA tests, overall CVSA accuracy dropped from 41% ($p > .05$) to 36% ($p > .05$). The changes in accuracy rates within each instrument category were not statistically significant.

Interrater Reliability

The frequency of agreements on serial position of the key number among evaluators for each subject was examined using the Kappa statistic for multiple ratings (Fleiss, 1981), the results of which are shown in Table 1. With the exception of position 4, agreement among evaluators was statistically significant for each possible position of the key item, as was overall agreement. However, the key numbers could be physically located only in positions 2 and 3, dependent on question padding.

Table 1

Interrater Agreement (Kappa) Among PDD and CVSA Evaluators

	Position					
	1	2	3	4	Not Scored	Overall
PDD	.26*	.58*	.52*	.02	.10	.46*
CVSA	.65*	.35*	.48*	.20*		.42*

* $p < .05$

Note. PDD = psychophysiological detection of deception; CVSA = computer voice stress analyzer.

General Discussion

The results of Experiment 1 indicate that the CVSA instrument detects discrete changes in the fundamental frequency of signals presented at its input, and displays those changes as observable differences in chart tracings. Data analysis of the results of Experiment 2 indicates that, under similar test conditions, the percent of correct subject veracity decisions

made using information gathered during a PDD examination exceeded the percent of correct subject veracity decisions made using information gathered during a CVSA examination by 23.8%--a statistically significant difference. These results suggest that, under the test conditions used, although the CVSA instrument performs electrically as theorized, it has less sensitivity to psychophysiological reactivity than the traditional polygraph instrument. These differences may be a function of the additive information, or Gestalt, provided by the multi-channel structure of the polygraph instrument versus the difficulties imposed by the single channel analysis of the CVSA, particularly when a conflict arises (e.g., none of the responses meet the decision criterion). Although, in certain situations, individual PDD examiners may rely heavily on one of the measures, it is not likely that an experienced examiner will be satisfied with a decision based on that single component. A power analysis conducted prior to beginning the study indicated that the design had a 0.90 probability of correctly detecting an effect of at least 0.25 different from chance if such an effect actually exists. Thus, failure to obtain subject veracity decision accuracy rates significantly greater than chance using the CVSA suggests that, under the test conditions used, there is a probability of at least 0.90 that the CVSA is not sensitive enough to accurately detect effects at a level of at least 0.25 greater than chance accuracy.

Scoring procedures seem to be as consistent for the CVSA as for the polygraph instrument, as suggested by the high interrater reliability for both instruments and associated procedures. However, Horvath (1978) obtained interrater agreements that were greater for one component of the traditional polygraph instrument than for the voice stress analyzer; $\underline{r} = .92$ for the GSR and $\underline{r} = .38$ for the PSE. This suggests that scoring biases may have played a major role in the interpretation of voice stress responses using the older instrument. Brenner and Branscomb (1979) submit that the problem of scoring subjectivity is serious enough to bring into question any specific legal decisions made regarding PSE results. In experiment 2, the absence of jeopardy, contrived or real, may have contributed to the low accuracy rates obtained using the polygraph and CVSA instruments and procedures. No incentives were offered to subjects to motivate them to act or react in a particular manner. It was not expected that subjects programmed deceptive would experience anything other than very low levels of stress when answering untruthfully about a previously selected number. This lack of jeopardy may have contributed to the fact that the CVSA instrument and procedures obtained an accuracy which was not significantly different from chance.

Visual analysis of the CVSA tests administered during subject testing revealed that responses were not as easily interpreted as those from the electronic laboratory study in Experiment 1. However, interpretation was consistent among evaluators, as evidenced by the high interrater reliability. Surprisingly, the CVSA accuracy results were comparable to those obtained in an earlier study (Cestaro & Dollins, 1994) using a similar numbers test paradigm. In that study, pitch and energy extraction techniques yielded an accuracy of 37% in a numbers test paradigm where chance level was 20%. Although the current study also showed that there may be a predictable relationship between measures of a voice component and stress, however weak, that relationship is not well understood. There is conflicting evidence related to the laryngeal microtremor hypothesis (Shipp & Izdebski, 1981; Smith,

1977). Even if that relationship were well established, it can only be indirectly assessed by examination of speech patterns, and the patterns can be affected by other endogenous or exogenous mediators such as, vocal tract pathology, ambient noise, instrument error (see Schoentgen & de Guchteneere, 1991). Increases in the magnitude of a subject's voice microtremor (an unstressed response) may be related to an underlying laryngeal pathology. Additionally, the use of cassette tape recorders for off-line analysis of voice responses for deception detection may be problematic due to distortions introduced by the recorder into the measurement of interest (Doherty & Shipp, 1988). This type of analysis has been popularized by the proponents of the CVSA. One or more of these mitigating factors, in concert with a weak stress-inducing laboratory paradigm, can have a serious effect on successful differential diagnoses of responses. Research substantiating the basic underlying theory, by comparing simultaneous vocal tract muscle activity and voice microtremor, has been minimal (e.g., Inbar & Eden, 1976). Additionally, there is limited research supporting the inverse relationship between microtremor and stress (e.g., Smith, 1977), and that relationship was indirectly assessed by examination of speech patterns.

The arguments for or against the use of voice stress analysis may ultimately be counterproductive. Such arguments do not consider its potential utility in the arsenal of tools for deception detection. Investigators should re-examine speech as an additional component rather than to assess it as a singular response channel. Except for the findings of Horvath (1978) related to GSR and PSE, it has not been established how the voice stress channel would perform when compared with each of the three channels currently employed in the traditional polygraph instrument. Atypical differential responding across the three archetypal channels (GSR, pneumograph, and cardiovascular) is common and is largely a function of individual differences in responders. As discussed previously, it is unlikely that an experienced PDD examiner would make a decision based exclusively on reactivity in one channel. The proponents of voice stress analysis are arguing for reliance on a single channel in making an extremely important decision. It would seem wiser to offer its potential utility as an adjunct to, rather than attempt to supplant, the traditional polygraph instrument. However, continuing research in this area should focus on: (1) the existence of laryngeal microtremor as assessed concurrently by EMG and speech pattern analysis; and (2) autonomic mediation of muscle microtremor, particularly laryngeal microtremor. It has been established that autonomic innervation extends primarily to cardiac and smooth muscle tissue (slow response). Some of the striate (fast response) muscle groups in the larynx are innervated by the vagus nerve (cricothyroid, arytenoid), but there is insufficient information available regarding the function of the vagal innervation.

In summary, the CVSA instrument has been shown to detect discrete changes in speech fundamental frequency, confirming NITV's underlying theory of operation. The accuracy of examiner decisions concerning subject veracity obtained using the polygraph instrument and procedures was significantly greater than both chance and that obtained using the CVSA instrument. The accuracy of examiner decisions concerning subject veracity obtained using the CVSA instrument and procedures was not significantly greater than chance. While the study design was sufficiently powerful to detect such differences had they existed, subjects

did not experience jeopardy during testing--as they would in the field. The lack of jeopardy may have contributed to the obtained relatively low accuracy rates for both instruments. Finally, interrater agreement for the CVSA and polygraph instruments and procedures were both relatively high and significantly better than chance--suggesting that the observed difference in accuracy rates are attributable to instrument/procedure sensitivity--or the lack thereof--rather than examiner test data evaluation skills.

References

Barland, G. H. (1974). Use of voice changes in the detection of deception. Polygraph, 7(2), 129-140.

Brenner, M. & Branscomb, H. H. (1979). The psychological stress evaluator; Technical limitations affecting lie detection. Polygraph, 8, 127-132.

Brenner, M., Branscomb, H. H., & Schwartz, G. (1979). Psychological stress evaluator--two tests of a vocal measure. Psychophysiology, 16(4), 351-357.

Cestaro, V. L., & Dollins, A. B. (1994). An analysis of voice responses for the detection of deception (Report No. DoDPI-94-R-0001). Fort McClellan, AL: Department of Defense Polygraph Institute.

Doherty, E. T., & Shipp, T. (1988). Tape recorder effects on jitter and shimmer extraction. Journal of Speech and Hearing Research, 31, 485-490.

Fleiss, J. L. (1981). Statistical methods for rates and proportions (2nd ed.). New York: John Wiley & Sons.

Gray, H. (1977). The organs of voice and respiration. In: T. P. Pick & R. Howden (Eds.), Gray's anatomy (pp. 955-983). New York: Gramercy Books.

Gustafson, L. A., & Orne, M. T. (1963). The effects of heightened motivation on the detection of deception. Journal of Applied Psychology, 47, 408-411.

Horvath, F. H. (1978). An experimental comparison of the psychological stress evaluator and the galvanic skin response in detection of deception. Journal of Applied Psychology, 63, 338-344

Horvath, F. H. (1979). Effect of different motivational instructions on detection of deception with the psychological stress evaluator and the galvanic skin response. Journal of Applied Psychology, 64, 323-330.

Horvath, F. H. (1982). Detecting deception: The promise and the reality. Journal of Forensic Sciences, 27, 304-318.

Inbar, G. F., & Eden, G. (1976). Psychological stress evaluators: EMG correlation with voice tremor. Biological Cybernetics, 24, 165-167.

Kahane, J. C. (1986). Anatomy and physiology of the speech mechanism. In: H. Halpern (Ed.), The Pro-Ed studies in communicative disorders, (pp. 78-93). New York: Pro-Ed.

Lieblich, I., Naftali, G., Shmueli, J., & Kugelmass, S. (1974). Efficiency of GSR detection of information with repeated presentation of series of stimuli in two motivational states. Journal of Applied Psychology, 59, 113-115.

Lippold, O. (1971). Physiological tremor. Scientific American, 224, 65-73.

Lynch, B. F., & Henry, D. R. (1979). A validity study of the psychological stress evaluator. Canadian Journal of Behavioral Science, 11, 89-94.

Motley, M. T. (1974). Acoustic correlates of lies. Western Speech, 81-87.

NITV. (1994). Certified Examiners Course Manual. (Available from the National Institute for Truth Verification, West Palm Beach, FL.

Schoentgen, J., & de Guchteneere, R. (1991). An algorithm for the measurement of jitter. Speech Communication, 10, 533-538.

Shipp, T., & Izdebski, K. (1981). Current evidence for the existence of laryngeal macrotremor and microtremor. Journal of Forensic Sciences, 26, 501-505.

Smith, G. A. (1977). Voice analysis for the measurement of anxiety. British Journal of Medical Psychology, 50, 367-373.

Streeter, L. A., Krauss, R. M., Geller, V., Olson, C., & Apple, W. (1977). Pitch changes during attempted deception. Journal of Personality and Social Psychology, 35(5), 345-350.

Tippett, R. G. (1995). Comparative analysis study of the CVSA and the polygraph. NITV Journal of Continuing Education, First Half 1995, 9-26.

Tolkmitt, F. J., & Scherer, K. R. (1986). Effect of experimentally induced stress on vocal parameters. Journal of Experimental Psychology, 12, 302-313.

VanDercar, D. H., Greaner, J., Hibler, N. S., Spielberger, C. D., & Block, S. (1980). A description and analysis of the operation and validity of the psychological stress evaluator. Journal of Forensic Sciences, 25, 174-188.

Zalewski, J., Majewski, W., & Hollien, H. (1975). Cross-correlation between long-term speech spectra as a criterion for speaker identification. Acustica, 34, 20-24.

Appendix A

Description of Research

WELCOME: Welcome to the Department of Defense Polygraph Institute. This may be the first time you have been to the Institute so we would like to provide you with some information concerning your visit today. PLEASE REMEMBER that your participation is entirely voluntary - you are free to leave at any time. If you have any questions, please feel free to ask the individuals assisting you.

Research Title: A Comparison of Accuracy Rates Between the Polygraph and the Computer Voice Stress Analyzer in the Absence of Jeopardy

Principal Investigator: Dr. Victor L. Cestaro, DoDPI Research Psychologist

BACKGROUND / SIGNIFICANCE: The Psychophysiological Detection of Deception (PDD) is a process believed to determine whether an individual is responding truthfully to a series of questions. PDD is commonly called "lie detection" or "polygraph" test. The process is based on the assumption that an individual who is deceptive (i.e., lying) has a greater response in some body systems than a person who is not. It is also proposed that there are certain characteristics in a person's voice that change when that person is being deceptive. The purpose of this research is to determine how well deception can be detected by voice characteristics when compared with the results of the polygraph instrument.

YOU SHOULD NOT PARTICIPATE IN THIS STUDY IF YOU:

1) Are taking prescription medication.
2) Have a history of dizziness or fainting spells.
3) Have been diagnosed with a heart condition.
4) Have been diagnosed with high blood pressure.
5) Have been diagnosed with a respiratory ailment, especially asthma or emphysema.
6) Currently suffer from an acute health problem such as a cold, active allergy problem, hemorrhoidal problem.

PROCEDURES: During this project you will be asked to participate in a two-part research session lasting approximately one half hour each. These two sessions will be separated by about 15 minutes. Before the first session begins, you will be asked to pick a number from a range of numbers, and write that number on a piece of paper. During each session you will be asked about the number you picked. You are not to answer truthfully about your number to the examiner during the PDD examination. YOUR TASK IS TO LIE SUCCESSFULLY, to the PDD examiner concerning the number you picked.

Participation in the PDD process is relatively simple. Some people will participate in the polygraph examination first, followed by the voice analysis examination, and others will take the examinations in the opposite order. The examiner will ask several questions concerning

your age, health, and normal daily activities. He will then briefly explain the theory of the Psychophysiological Detection of Deception and review the questions he will ask during the examination with you. With your permission, the examiner will then attach sensors to your body before the polygraph examination begins. Two small flat metal sensors will be attached to the first and third fingers of one hand. Expandable tubes will be put around your upper and lower chest. A blood pressure cuff will be wrapped around your arm. You will be asked to sit still for several minutes while the examiner asks the questions he reviewed earlier. When the session is complete, you will be escorted to another examination room to begin the voice analysis session. The second session will be like the first except that no sensors will be attached to your body. Instead, a small microphone will be placed on your chest and held in place with a lavaliere cord. In some cases, the voice analysis examination will be given first, followed by the polygraph examination.

DISCOMFORTS: Some people find it difficult to sit still for several minutes at a time during the PDD test while physiological reactions are recorded. Part of the PDD process requires the wearing of an inflated blood pressure cuff, which some people find moderately uncomfortable. The examiner is sensitive to this discomfort and will attempt to make the process as brief as possible. The actual test lasts approximately five minutes. The total length of time that you will actually be participating in the polygraph examination and the voice analysis examination is 45 minutes to an hour, however, you may be at DoDPI for two or three hours.

VIDEOTAPING: All examinations conducted during this project will be videotaped using wall and ceiling mounted video cameras and commercial videotape recorders. The tapes collected will be maintained until the operational and data analysis portions of the project are complete. At that time the video tapes will be erased and made available for re-use by the research and instruction divisions.

RISKS: There are no known risks involved in this study.

CONFIDENTIALITY OF RECORDS: You will not be asked any personal questions by the examiner, except medically related information necessary for this study. Neither your identity nor any information you reveal during this project will be released to anyone not directly involved in the research. Members of the U.S. Army Surgeon General's Human Subjects Research Review Board may inspect the research records in their capacity as reviewing officials.

YOUR RIGHTS: You have the right to ask any questions about any aspect of your participation in the study. If any problems arise at any time in conjunction with your involvement in the study, or if you have been injured in any way as a result of the study, the person to contact is the Chief of Research, Department of Defense Polygraph Institute. In the event that you do have questions or any of the above has occurred please contact Dr. William Yankee at (205) 848-3803. Should any question arise concerning study-related

injury, you may contact the Director of the Noble Army Community Hospital, Fort McClellan, Alabama, 36205, telephone number (205) 848-2200.

VOLUNTARY PARTICIPATION: Your participation in this study is completely voluntary. **If you would prefer not to participate, do not volunteer for it!** Even if you decide to participate in the study, you may discontinue at any time without penalty or loss of benefits to which you are entitled. Should you decide not to participate, please inform someone on the staff at the Department of Defense Polygraph Institute, or if it occurs during the polygraph examination itself, inform the examiner and you will be released without censure.

ADDITIONAL COMMENTS: It is VERY IMPORTANT that you do not discuss your experiences in the PDD examination with your fellow research participants. If that occurs, you will be withdrawn from the study without further benefit.

Appendix B

Informed Consent Affidavit

This form is affected by the Privacy Act of 1974.

1. **AUTHORITY:** 10 USC 3013, 44 USC 3101 and 10 USC 1071-1087 and E.O. 9397.

2. **PRINCIPLE PURPOSE:** To document voluntary participation in the Clinical Investigation and Research Program.

3. **ROUTINE USES:** The SSN and home address will be used for identification and locating purposes. Information derived from the study will be used to document the study, adjudication of claims, and for mandatory record keeping associated with human use in government research. Information may be furnished to Federal agencies.

4. **DISCLOSURE:** Voluntary. Failure to furnish requested information will preclude your voluntary participation in this investigational study.

PERSONAL STATEMENT

I, ________________________________, being at least 19 years old, do hereby volunteer to participate in a research study titled "A Comparison of Accuracy Rates Between the Polygraph and the Computer Voice Stress Analyzer in the Absence of Jeopardy" being conducted at the Department of Defense Polygraph Institute, under the direction of Victor L. Cestaro, Ph.D.

1._____ I understand that I am participating in a research study to examine several measures and techniques, some of which are currently employed in criminal and/or security screening situations where the Psychophysiological Detection of Deception (PDD) is used. PDD is commonly called a 'polygraph test' or 'lie detector'. My voice will also be analyzed with a Computer Voice Stress Analyzer.

2. To the best of my knowledge,

A._____ I am not taking any prescription medication.

B._____ I have no history of dizziness or fainting spells.

C._____ I have not been diagnosed as having, nor do I believe that I may have any of the following:

1) Heart condition.
2) High blood pressure.
3) Any respiratory ailment, especially asthma or emphysema.

D._____ I do not now have any acute health problems such as a cold, an active allergy problem, and an active hemorrhoidal problem.

3._____ I am aware that I will be spending approximately two (2) hours at the DoD Polygraph Institute (DoDPI) on one occasion, and that I may be asked to conceal specific information from a trained Forensic Psychophysiologist.

4._____ I understand that as a part of this study I will be participating in a PDD examination during which I will be asked to sit still for several minutes at a time while physiological measurements are recorded from my body.

5._____ I understand that there are no known dangers or risks associated with my participation in this study.

6._____ I understand that I will be required to wear an inflated blood pressure cuff, which some people find moderately uncomfortable, during the PDD examination.

7._____ I understand that I will be videotaped during the PDD examinations and that the videotape will be maintained until data analyses are complete.

8._____ I understand that I will receive no reward or benefit of any kind as a result of my participation in this study.

9._____ I understand that I may terminate my involvement in this study at any time and for any reason, without censure.

10._____ I understand that my participation in this project will be terminated if I discuss the details of my participation with anyone except project supervisory personnel. NOTE: Discussion of details with other participants would invalidate the data collection.

11._____ I understand that I should contact the principal investigator, Dr. Victor L. Cestaro, and / or the DoD Polygraph Institute Director, Dr. William Yankee [Tel: (205) 848-3803] if I have any concerns or complaints regarding this study.

12._____ I understand that any questions concerning my rights relating to study-related injury should be directed to Colonel Weisser, MD, Director of the Noble Army Community Hospital, Fort McClellan, Alabama, 36205 [Tel (205) 848-2200].

13._____ I have been given a thorough explanation of the nature, purpose, methods, and duration of my participation in this investigation. I have been given the opportunity to ask any questions I have concerning the investigation and all questions have been answered to my full satisfaction.

__________________________	__________________________
Participant Signature	Witness Signature
__________________________	__________________________
Printed Name	Printed Name
__________________________	__________________________
Date	Date

Appendix C

Pre-Test Questionnaire

Participant number:________ Date of completion:_______

Please carefully complete all of the blanks below:

Name (Please Print):_________________________________Gender:( )M ( )F

Occupation:_________________________________ Age:______

Hours of sleep last night:_____

Previous PDD Examination: ( )Yes ( )No

Have you ingested alcohol, nicotine, or caffeine (including coffee, tea, soft- drinks, and chocolate) within the last 24 hours? ( )Yes ( )No

If so, what and when? ____

____

How would you describe your present health and physical well being?
( )Excellent ( )Good ( )Fair ( )Poor

Are you presently under a physician's care and are you taking any medication?
( )Yes ( )No

If so, for what condition?___________________________

Please identify the type, dosage, and last time any medication was taken:

____

Are you experiencing any pain or discomfort today?
( )None ( )Mild ( )Moderate ( )Severe

Reason for any pain or discomfort today_____________

Appendix D

Participant Debriefing Statement

Now that you have completed your role in our research, it is the desire of the entire project staff to take this opportunity to sincerely thank you for your help. Your work here may be more important than you realize.

The results of this study may include information which will provide federal agencies and police departments with a better understanding of how to change existing PDD examinations to accurately determine when an individual is being truthful.

If you participated in deceiving the PDD examiner, you are assured by the staff of this institute, that you in no way violated any rule or law. The deception was required for investigational purposes only.

Regardless of the role you played, it is our hope that you were made to feel as comfortable as possible throughout the study. If you do have concerns or questions regarding your participation, please make them known to the principal investigator, Dr. Victor Cestaro, and/or the DoD Polygraph Institute Director, Dr. William Yankee [Telephone number: (205) 848-3803].

Finally, it is VERY IMPORTANT that you DO NOT discuss the details of this study with anyone else. One of your friends, or a friend of a friend, may decide to participate in this or a similar study someday. If they know the details of the investigation process, they could be disqualified from participating in a study and/or unconsciously influence the results of the study using their GUILTY KNOWLEDGE.

Please sign this form in the space provided to indicate that you understand the instructions provided above.

____

Participant Signature

____

Printed Name

____

Date

Appendix E

Polygraph Pre-Test Interview

Good morning (afternoon), my name is ________________ and I will be conducting the polygraph examination today. I am a Forensic Psychophysiologist and like you I have been detailed to assist Dr. Cestaro in this very import research project. You and I know that this project is very important otherwise the Army would not have provided us to participate.

Before we begin conducting any examinations I will explain everything that will be attached to you for this examination and we will have discussed a little bit about your background and one of the theories of psychophysiological detection of deception. Let me assure you that nothing will be said or done here that will in any way hurt or injure you. Do you have any questions before we proceed?

Now, I would like to complete the interview work sheet.
[Review Pre-Test Questionnaire - Appendix C]

One of the theories concerning the psychophysiological detection of deception or the ability of a trained forensic psychophysiologist (polygraph examiner) to diagnose deception is that of Fight or Flight which you may be familiar with from sports and your training in the military. This phenomenon is theorized to be what allows us to survive in dangerous or stressful situations. When the mind recognizes that we are in danger we enter into Fight or Flight and the naturally occurring substance epinephrine is released into the blood stream. Epinephrine effects different organs of the body in different ways. In the case of the cardiovascular system this substance causes the activity of the heart to increase along with a marked increase in the pulse, blood pressure, and other cardiac activity.

In the case of the heart the increases are to provide more oxygen and nutrients to the large muscles of the legs and arms so we can run away from the problem or fight our way out of the problem. Additionally this provides more oxygen to the brain so we can think our way out of the problem. The epinephrine additionally effects our lungs by causing them to increase activity to better place oxygen in the blood stream and to remove carbon dioxide from the system.

The body experiences numerous other physiological changes to include changes in the sweat gland activity and the electrodermal activity at the skin. Normally these reactions are associated with fear. These reactions are what allow us to survive in stressful situations such as combat, parachuting, and other duties.

[The Examinee is then asked to provide an example of when they might have experienced this phenomenon. Common examples were as follows: 1st traffic citation; combat in South West Asia; traffic accidents; and, training mishaps.]

Well, I can tell by your example that you are familiar with these reactions. The same type of reactions occur when we are practicing deception because there is a fear of being caught in an untruthful statement or being punished for the untruth. Have you ever experienced these reactions?

Once we have told the deception another drug is released into the blood stream which brings the body back to normal. This drug is called nor-epinephrin. This same drug aids in our recovery from dangerous situations.

With the sensitive apparatus associated with a polygraph instrument a trained polygraph examiner can diagnose when an individual has been less than truthful when answering questions while attached to the instrument. The actual attachments you that will be placed on your body are the standard hospital blood pressure cuff, to monitor your cardiac activity. Two small metal plates which will be attached to you finger tips to monitor your sweat gland activity, and two convoluted tubes which will be placed around your torso to monitor you respiratory activity. None of these attachments will cause you any pain or discomfort.

The examiner then conducts the stimulation test.

Appendix F

Test Questions

CVSA Questions

Q01	IR	Are we in Alabama?
Q02	IR	Am I wearing a tie?
Q03	R	Regarding the number you wrote on that piece of paper, did you write the number 2?
Q04	IR	Are you wearing a hat?
Q05	R	Did you write the number 3?
Q06	IR	Is this year 1994?
Q07	R	Did you write the number 4? (KEY A)
Q08	IR	Are we at Fort McClellan?
Q09	R	Did you write the number 5? (KEY B)
Q10	IR	Am I wearing a watch?
Q11	R	Did you write the number 6?
Q12	IR	Is my shirt white?
Q13	R	Did you write the number 7?
Q14	IR	Am I wearing glasses?

Polygraph Questions

Regarding the number you wrote on that piece of paper,

Q01	Did you write the number 2?
Q02	Did you write the number 3?
Q03	Did you write the number 4? (KEY A)
Q04	Did you write the number 5? (KEY B)
Q05	Did you write the number 6?
Q06	Did you write the number 7?

Appendix G

CVSA Pre-Test Interview

Good morning (afternoon), my name is ________________ and I will be conducting the computer voice stress examination today. I have been trained and certified in the use of the Computer Voice Stress Analyzer and have been detailed to assist in this very important research project. You and I know that this project is very important otherwise the Army would not have provided us to participate.

Before we begin conducting any examinations we will have discussed a little bit about your background and one of the theories of psychophysiological detection of deception. Let me assure you that nothing will be said or done here that will in any way hurt or injure you. Do you have any questions before we proceed?

Now, I would like to complete the interview work sheet.
[Review Pre-Test Questionnaire - Appendix C]

One of the theories concerning the psychophysiological detection of deception or the ability of a trained forensic psychophysiologist (polygraph examiner) to diagnose deception is that of Fight or Flight which you may be familiar with from sports and your training in the military. This phenomenon is theorized to be what allows us to survive in dangerous or stressful situations. When the mind recognizes that we are in danger we enter into Fight or Flight and the naturally occurring substance epinephrine is released into the blood stream. Epinephrine effects different organs of the body in different ways.

The body experiences numerous physiological changes to include changes heart rate, in the sweat gland activity and the electrodermal activity at the skin. Normally these reactions are associated with fear. These reactions are what allows us to survive in stressful situations such as combat, parachuting, and other duties by providing the brain and certain muscles with additional blood and oxygen, and by removing carbon dioxide from the system.

[The Examinee is then asked to provide an example of when they might have experienced this phenomenon. Common examples were as follows: 1st traffic citation; combat in South West Asia; traffic accidents; and, training mishaps.]

Well, I can tell by your example that you are familiar with these reactions. The same type of reactions occur when we are practicing deception because there is a fear of being caught in an untruthful statement or being punished for the untruth. Have you ever experienced these reactions?

It is also believed that this Fight or Flight response can affect certain aspects of our speech patterns that cannot be detected by the unaided ear. Special equipment has been designed and built that is able to detect and analyze those patterns. Today we will use an instrument

designed for this purpose to determine whether you are being less than truthful during a voice stress examination.

The examiner then conducts the CVSA peak-of-tension test.

Appendix H

CVSA Scoring Instructions

Test Format: CVSA Peak-of-Tension
There is at least one padding number before and one padding number after the key number.

Number of Questions: 14 (6 relevant numbers)

Instructions:

1. Numerically score all responses after the first two irrelevant questions. Write the score above the response. Scores should conform to NITV's accepted scoring practice with percentages falling into the following range criteria: peaking/diagonal (50%-79%), tendency to block (80%-83%), medium block (84%-89%), hard block (90%-100%).

2. Pick the response, by position number*, having the highest percentage of blocking. The greatest response can fall on a relevant or its irrelevant. Write that position number at the bottom right hand corner of the chart page.

*Position Numbers

POSITION	01-02-03-04-05-06-07-08-09-10-11-12-13-14
QUESTION	IR-IR-R1-IR-R2-IR-R3-IR-R4-IR-R5-IR-R6-IR